Pa Patient Saf Advis 2018 Dec;15(4).

Perioperative Medication Errors: Uncovering Risk from Behind the Drapes

Authors

Kayla H. Cierniak, PharmD, MS, BCPS

Medication Safety Analyst

Michael J. Gaunt, PharmD

Sr. Medication Safety Analyst

Matthew Grissinger, RPh, FISMP, FASCP

Manager, Medication Safety Analysis

Pennsylvania Patient Safety Authority

Corresponding Author

Matthew Grissinger

Abstract

Medication use in the perioperative setting presents unique patient safety challenges compared with other hospital settings. For example, perioperative medication prescribing and administration often bypasses standard safety checks, such as electronic physician order entry with decision support, pharmacy verification of specific drugs before administration, and multiple nursing checks at the time of medication administration. A total of 1,137 medication error events associated with the perioperative settings (e.g., operating room, anesthesia, postanesthesia care unit) were identified by analysts in event reports to the Pennsylvania Patient Safety Authority that occurred during calendar year 2017. More than half (54.6%, n = 621) of reported events reached the patient. Nearly three-quarters (74.9%, n = 852) of events were attributed to a breakdown in the communication process during transitions of care or handoff procedures. Other common contributing factors involved problems with the medication ordering process, as well as improper handling of medications leading to mix-ups and accidental administration of high-alert medications. Organizations may use this data to inform proactive efforts to standardize protocols in the perioperative setting and prevent similar errors from occurring.

Introduction

Although medication errors are preventable, they occur frequently, inflict patient harm, and incur costs ranging from $600,000 to upwards of $5.6 million per hospital each year.[1] In the perioperative setting, providers contend with time constraints and high-stress surgical procedure management that present unique medication safety challenges, compared with general medical-surgical patient care areas.[2]

The perioperative setting necessitates patient movements across a continuum of healthcare settings, involving multiple providers and interdisciplinary teams.[3] Multiple handoffs are required to transfer patient care responsibilities from one care setting to the next.[4] This process introduces opportunities for inadequate information exchange or loss. The transitory nature of the perioperative patient care path—coupled with multiple healthcare providers handling several drugs and caring for multiple patients simultaneously with the potential for limited oversight and work-related fatigue—raises concern for the possibility of medication errors, including errors of high severity.[5] Also, in the operating room (OR), very rapid responses may be required of healthcare providers to administer and titrate medications.

According to a prospective 2016 analysis of perioperative medication errors in a large health system, one error was found to occur in every other operation (i.e., 50% of surgeries involved at least one medication error), or in 1 out of every 20 perioperative medication administrations.[6] More than one-third of these errors led to observed patient harm. The remaining two thirds had potential for patient harm.

Improving medication safety in the OR (i.e., labeling medications on the sterile field) was added by the Joint Commission as a National Patient Safety Goal in 2007 and remained a goal in the 2017 update, as the current literature suggests there is much work yet to be done in this arena.[7] A mandate for improving effectiveness of communication, including implementing a standardized approach to handoff communications, was added in 2006 and still remained in the 2017 update.[7,8] This is also echoed in the 2013 Accreditation Council for Graduate Medical Education (ACGME) common program requirements, in which it is specified that programs must ensure residents are proficient in the handoff process.[9]

Events reported to the Pennsylvania Patient Safety Authority through the Pennsylvania Patient Safety Reporting System (PA-PSRS) are used to inform changes in clinical practice, with the intent of reducing the quantity and severity of future patient safety events.[10] Analysts reviewed medication errors that occurred in perioperative settings to identify factors contributing to events in these settings and propose system-based risk reduction strategies.

Methods

Analysts queried the PA-PSRS database for medication error events associated with perioperative settings that occurred from January 1, 2017, through December 31, 2017. To identify perioperative event reports, analysts queried the PA-PSRS care area type field for the specific, predefined care areas of "Anesthesia," "Operating Room," and "Post-Anesthesia Care." Analysts combined query results categorized as "anesthesia" and "OR" into one new category called "intraoperative" for simplification.

The reporting facilities provided the medication names, routes of administration, patient care area, event description, and PA-PSRS harm score[11] (adapted from the National Coordinating Council for Medication Error Reporting and Prevention [NCC MERP] harm index[12]). In addition to reviewing events that reached patients (harm scores C through I), analysts examined reports of hazardous conditions (harm score A) and good catches (harm scores B1 and B2).

If the medication name was not reported in the specified field, an analyst adjusted the field if the medication name was provided within the free text of the event description. Medication error events reported through PA-PSRS database with the subtype "Other" were subcategorized by analysts into more specific categories. The event description, medication error cause, and event recommendation fields were further reviewed for common themes and contributing factors associated with the events reported.

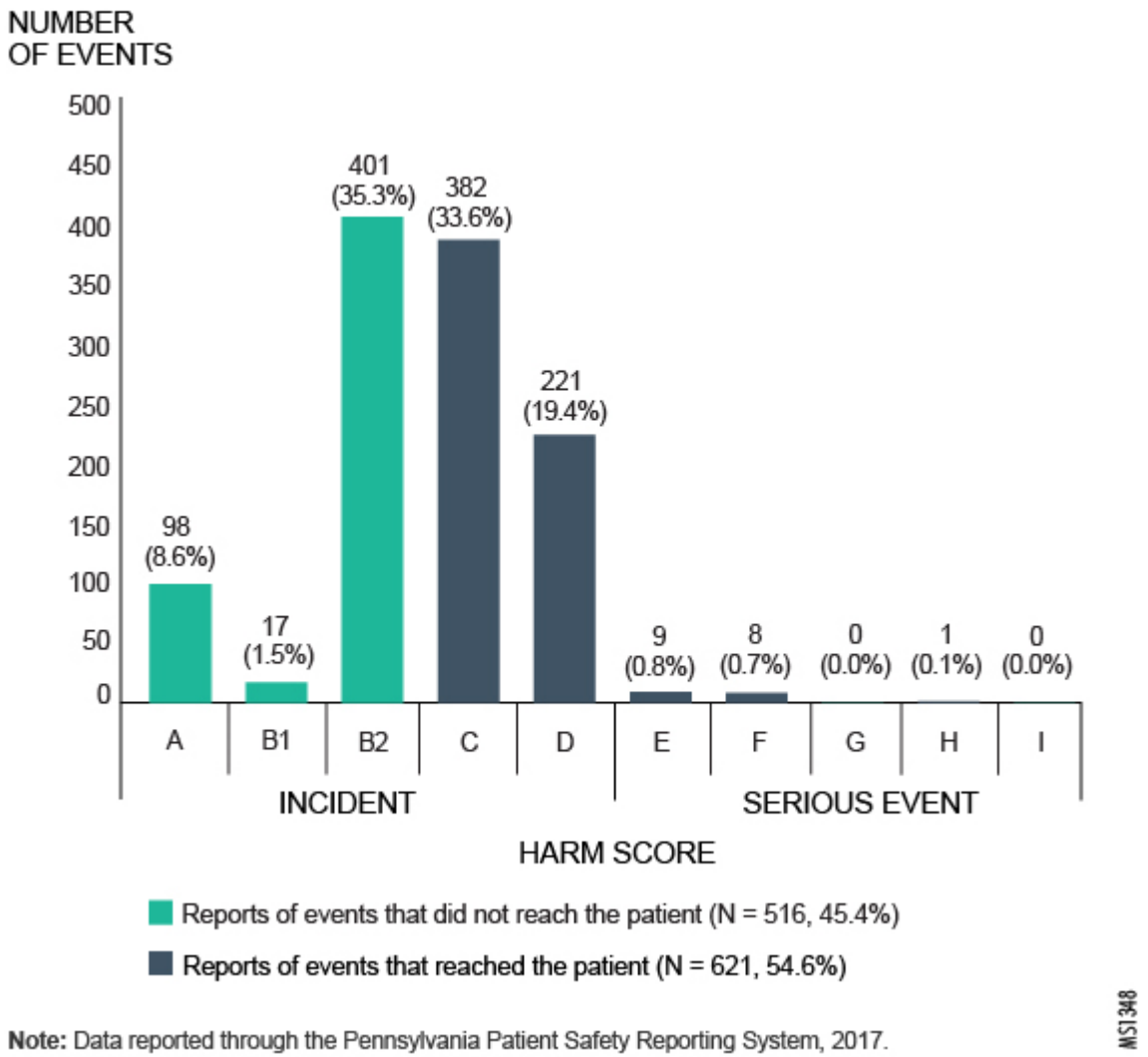
Results

The query yielded 1,137 reports from the PA-PSRS database concerning potential or actual medication errors. Most of the reports originated from acute care facilities (69.2%, n = 787 of 1,137) and children's hospitals (27.6%, n = 314). A much smaller percentage were reported in ambulatory surgical facilities (2.8%, n = 32) and critical access hospitals (0.4%, n = 4).

Almost three-quarters (73.0%, n = 830) of reports were from the intraoperative setting (i.e., categorized by reporters as occurring in anesthesia or the OR). The remaining 27.0% (n = 307) of reports were attributed to events in the postanesthesia care unit (PACU).

Figure 1 shows that when stratified by PA-PSRS harm score, 54.6% (n = 621) of events reached the patient (harm score = C through I) and 1.6% (n = 18) resulted in patient harm (harm score = E through I).

Figure 1. Reported Harm Scores for Medication Error Events Occurring in Perioperative Settings (N = 1,137)



Note: Data reported through the Pennsylvania Patient Safety Reporting System, 2017.

When medication safety systems otherwise fail, good catch programs within organizations improve patient safety.[13] A *good catch* is defined as "an event or circumstance that has the potential to cause an incident but that did not actually occur due to corrective action and/or timely intervention."[14] Good catches (events with harm scores B1 or B2) comprised more than a third (36.8%, n = 418) of the total.

The following are examples of good catch reports in the perioperative setting submitted through PA-PSRS:*

Patient received 2,000 mg vancomycin. Subsequently went to the OR, where another 2,000 mg was given [4 hours later] as per the anesthesia record. These doses were given too close together, as vancomycin should not be dosed more frequently than q 8-12h initially in such a patient. Contacted [resident] and she stated that it was only the initial dose of vancomycin that was restarted, and the patient did not get an extra dose.

Heparin order not given in ER [emergency room] when circulating nurses checked EMAR [electronic medication administration record] prior to patient coming to OR. Physician in OR placed an OR heparin order. Prior to OR nurses administering OR dose, EMAR checked again and ER dose had been administered promptly in the ER. Patient nearly received 2 doses of heparin.

The top PA-PSRS event medication error subtypes, as assigned by each reporter, are listed in Table 1. The three event subtypes most frequently reported were "Other," "Wrong dose/over dosage," and "Dose omission."

Table 1. Most Common Medication Error Event Subtypes as Assigned by Reporting Healthcare Facilities (N = 1,137)

EVENT TYPE	**NO. (%)**
Other	231 (20.3)
Wrong dose/over dosage	116 (10.2)
Dose omission	111 (9.8)
Wrong time	106 (9.3)
Wrong drug	90 (7.9)
Prescription/refill delayed	87 (7.7)
Wrong dose/under dosage	61 (5.4)

Note: Data reported through the Pennsylvania Patient Safety Reporting System, 2017. Percentages in the table are based on N = 1,137. The number of events (n = 802 of 1,137, 70.5%) represented in the table correspond to the most common event types as assigned by reporting healthcare providers.

Medication error event subtypes reported as "Other" by healthcare providers were reviewed and subcategorized by analysts (Table 2). The most common error types found included wrong frequency, drug omission, inappropriate wasting of narcotic medications, expired medications, and errors associated with improper labeling practices.

Table 2. Most Common Subcategories of Events Identified by Analysts in Reported Medication Error Event Subtype "Other" (N = 231)

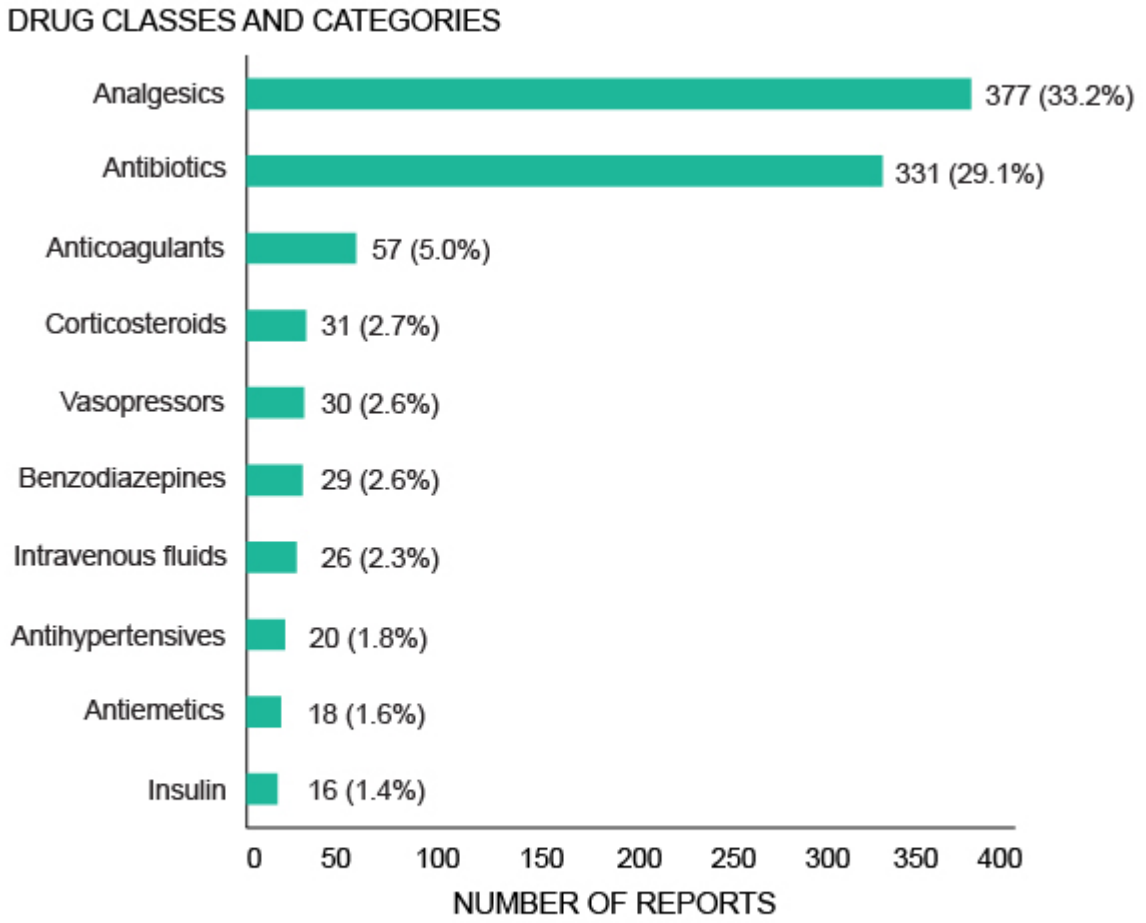
TYPE OF EVENT	**NO. (%)**
Wrong frequency	52 (22.5)
Dose omission	29 (12.6)
Inappropriate narcotic wasting	22 (9.5)
Expired drug	18 (7.8)
Mistake due to poor medication labeling practice	16 (6.9)
Documented allergy	12 (5.2)
Improper storage of medication	12 (5.2)

Misprogramming or mishandling of infusion pump	12 (5.2)
Wrong dose/over dosage	12 (5.2)
Extra dose	11 (4.8)

Note: Data reported through the Pennsylvania Patient Safety Reporting System, 2017. Percentages in the table are based on N = 231. The number of events (n = 196 of 231, 84.8%) represented in the table correspond the most common type of event identified by analysts from reports submitted as event type "Other."

As Figure 2 shows, the two most common classes of medications involved in errors were analgesics (33.2%, n = 377 of 1,137) and antibiotics (29.1%, n = 331). Of the errors involving analgesics, 53.3% (n = 201 of 377) were non-opioid and 44.0% (n = 166) were opioid medications. The analgesic and antibiotic associated with the most errors out of total reports were acetaminophen (7.3%, n = 83 of 1,137) and cefazolin (15.1%, n = 172), respectively.

Figure 2. Most Common Drug Classes and Categories Involved in Medication Error Events in the Perioperative Setting (N = 1,137)



Note: Data reported through the Pennsylvania Patient Safety Reporting System, 2017. Percentages are based on N = 1,137. The number of events shown (n = 935 of 1,137, 82.2%) correspond to the 10 most common drug classes and categories involved in medication error events occurring in the perioperative setting.

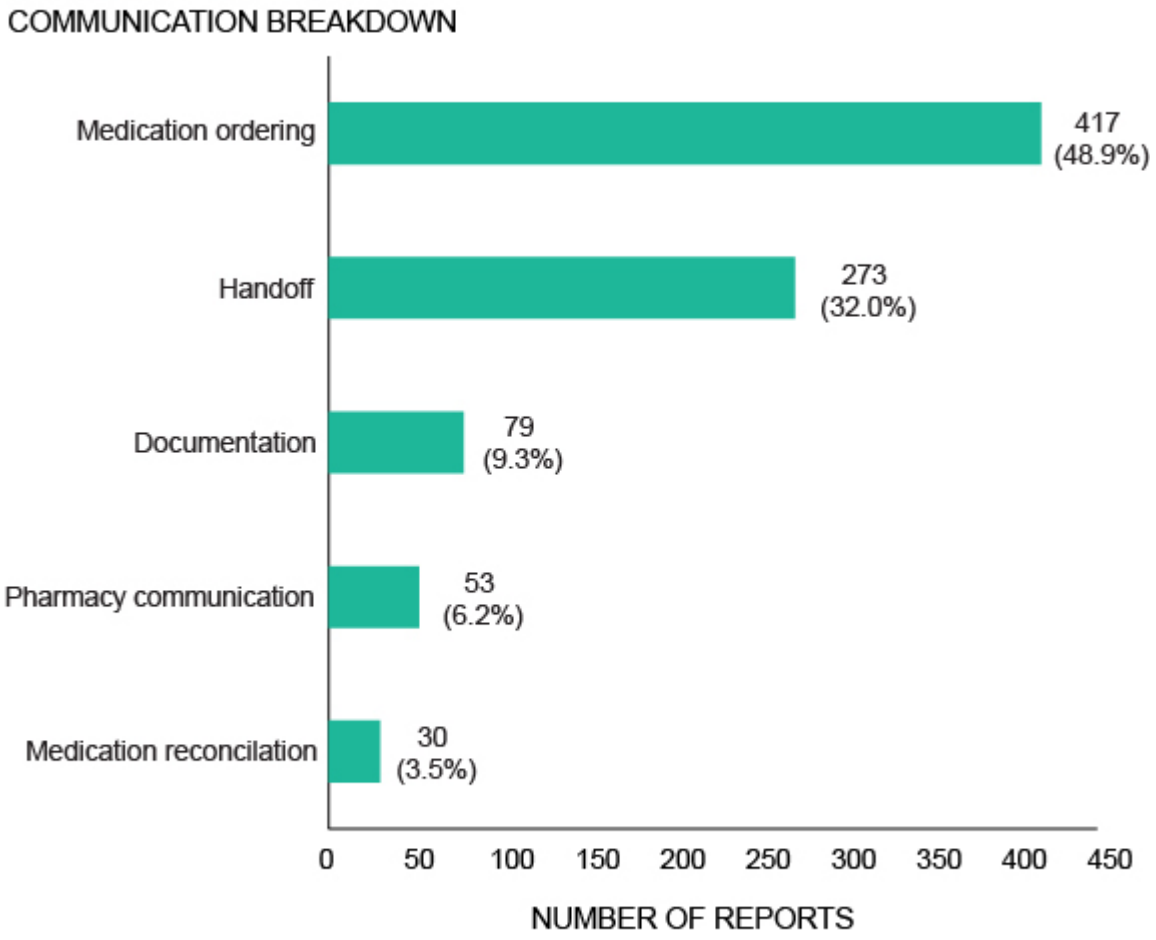
MSI349

High-alert medications, or medications that pose an increased risk of patient harm when involved in medication errors,[15] were cited in fewer than half (43.7%, n = 497 of 1,137) of reported events. More than one-half (51.7%, n = 257 of 497) of reports concerning errors with high-alert medications involved analgesics. These included opioids, parenteral nerve blocks, and bupivacaine epidurals.

Communication

Three-quarters of all reports (74.9%, n = 852 of 1,137) were attributed to a communication breakdown and then subcategorized into communication breakdown types (Figure 3). Half of these errors were associated with the medication ordering process (48.9%, n = 417 of 852).

Figure 3. Communication Breakdowns in Medication Error Events Occurring in the Perioperative Setting (N = 852)



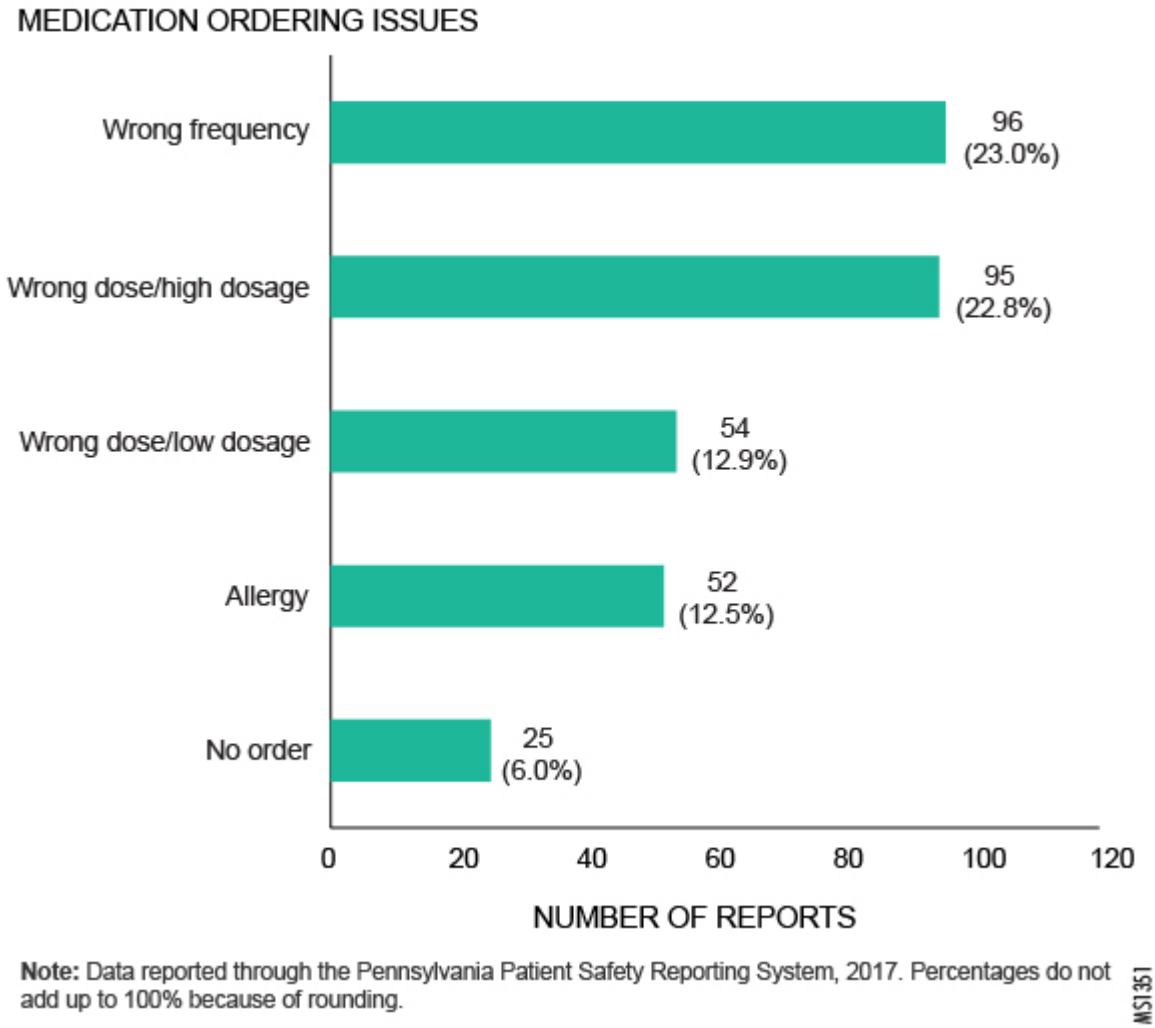
Note: Data reported through the Pennsylvania Patient Safety Reporting System, 2017. Percentages do not add up to 100% because of rounding.

MSI350

Medication Ordering Process

More than a third (36.7%, n = 417 of 1,137) of total events appeared to be related to some type of issue or error in the medication ordering process at the point of prescribing. This includes errors associated with computerized physician order entry (CPOE) systems and the electronic health record (EHR). The most common types of errors attributed to inappropriate medication ordering included wrong frequency, wrong dose (dose too high or too low), and ordering a medication to which a patient had an allergy (Figure 4).

Figure 4. Most Common Medication Ordering Issues Involved in Medication-Error Events Occurring in the Perioperative Setting (N = 417)



Note: Data reported through the Pennsylvania Patient Safety Reporting System, 2017. Percentages do not add up to 100% because of rounding.

MS1351

Errors in dosing frequency comprised 23.0% (n = 96 of 417) of these reports. More than half (58.3%, n = 56 of 96) of these were antibiotic frequency errors.

An inappropriately high dose was ordered in 22.8% (n = 95 of 417) of these events. A lower dose was inappropriately ordered in 12.9% (n = 54) of these events. In total, these wrong dose errors accounted for 35.7% (n = 149) of total ordering errors.

In 49 reports the ordered dose was too high for analgesics (51.6%, n = 49 of 95), including 5 involving patient controlled analgesia (PCA). Following is an example of a medication ordering error:

Patient ordered a HYDROmorphone PCA by Surgical services. PCA when ordered the first time by resident was ordered mcg/kg that is not allowed as per our policy. When discussed and reordered the PCA was then ordered without an hour limit. PCA to be reordered for the third time. Now waiting for correct PCA order for over one hour.

Prescribers ordered a medication to which the patient had a documented allergy in 12.5% (n = 52 of 417) of the medication-ordering events. The patient received the medication in most (80.8%, n = 42 of 52) of these cases. In 30.8% (n = 16) of events in which a patient was unintentionally administered a medication to which he or she had a documented allergy, a prophylactic medication was administered (e.g., IM diphenhydramine), additional monitoring was implemented, or the patient exhibited signs of allergic reaction that required intervention. The following are examples of reports in which ordering errors involving allergies reached the patient:

Patient had allergy to Dilaudid® [HYDROmorphone] listed. Anesthesiologist asked patient what type of reaction—patient stated warm feeling. Physician ordered Dilaudid and pharmacy overrode the order in computer. Patient was administered Dilaudid, reported hallucinations and feeling hot, and began to shake. Anesthesiologist at bedside. Vital signs normal. Patient's son very upset patient was administered Dilaudid.

The graft that was used for acl [anterior cruciate ligament] reconstruction was soaked in bacitracin irrigation for few minutes. When we started the case that's when I saw that she's allergic to Neosporin® (contains bacitracin). I immediately informed anesthesia and the surgeon. We took the graft out from the basin and rinsed it well with 0.9 NaCl.

Poor or Inadequate Handoff

Poor or inadequate handoffs were identified in 24.0% (n = 273 of 1,137) of event reports. Almost half (44.7%, n = 122 of 273) of these events involved dose omission. The most commonly omitted drugs were antibiotics (51.6%, n = 63 of 122) and analgesics (15.6%, n = 19).

The following examples demonstrate dose omissions or severely delayed medication administration due to lack of appropriate handoff when transitioning from one care area to the next:

Patient to OR. 2 units PRBC [packed red blood cells] ordered to be transfused with a single IV [intravenous] dose of Lasix® [furosemide] 40 mg to be given after the first unit transfusion was completed. Normal protocol is that the blood is transfused prior to transport to OR; however, the patient was transferred to the PACU as holding to expedite the procedure. Floor nurse gave report to the PACU nurse that the Lasix needed to be given. PACU nurses do not normally give report to OR nurse. Patient was transferred to the OR and information was not communicated. 2nd unit was hung without Lasix being given. After surgery the patient developed respiratory distress due to pulmonary edema that was secondary to transfusion and fluid overload. Patient required reintubation and transferred to ICU [intensive care unit].

Patient arrived to the CCU [critical care unit] off Inhaled nitric [oxide] which was started in the OR. Patient transported from OR to CCU off medication. Patient arrived with sats [oxygen saturation] of 84% requiring increase in FiO_2 [fraction of inspired oxygen] to 100%. Inhaled nitric [oxide] restarted in room and sats recovered.

Hydrocortisone was ordered to be given in the OR and it wasn't given. The patient's midline [catheter] was also left not heplocked. The patient returned to the unit from the OR with a clotted midline so she did not have IV access to give the needed hydrocortisone and a bolus for low blood pressure.

Patient on dialysis underwent revision of her AVF [arteriovenous fistula] with resulting labs in PACU (at 2 am) showing a K+ [serum potassium] of 5.9. Emergent dialysis was discussed and deferred until morning with interval plan to give insulin and glucose to temporize hyperkalemia while checking labs in 2 hours. This was ordered STAT as both a floor and PACU medicine in [the EHR] while patient was still in PACU. The medicine was never given in PACU and was never signed out to receiving nurse on floor.

Another type of handoff issue was due to errors involving the wrong patient (21.6%, n = 59 of 273). Typical event narratives described patients arriving from one care area to the next with the incorrect medication infusing or placement of the wrong patient sticker on a patient's order sheet.

In 10 reports (16.9%, n = 10 of 59), wrong-patient errors occurred due to incomplete handoffs when scheduling cases. In eight (80%) of these handoffs events, a patient was premedicated and sedated for a procedure at the wrong time, resulting in patients being sedated for longer than necessary.

Inadequate handoffs also led to administration of a double dose to patients (19.0%, n = 52 of 273). For example, one dose was given in one care area (e.g., the ED) and then a second dose was given after the patient had been transferred to the next care area (e.g., the OR). Providers administering the second, inappropriate dose were typically unaware that the previous dose had been given. Following is an example when rapid transitions of care resulted in a triple dose of ciprofloxacin:

Patient given dose of IV Cipro® [ciprofloxacin] 400 mg upon presentation to ED for perirectal abscess at 1500; surgery consulted and surgeon ordered Cipro q12h; post op noted as reason for use; pharmacist consulted. Next dose scheduled for 0000. In the meantime, nursing in PACU/preop overrode dose and gave prior/at beginning of surgery. This resulted in patient receiving 3 x 400 mg IV doses of Cipro in about 8 hours [in the ED, PACU, and on the floor].

Inaccurate or Incomplete Documentation

In 9.3% (n = 79 of 852) of events related to communication breakdown, there was an issue with inaccurate or incomplete documentation of medication administration. Inaccurate documentation often leads to subsequent errors, such as instances described above in which repeated doses have been administered because the previous dose was not recorded[16] or was not recorded promptly. The following are examples of documentation errors:

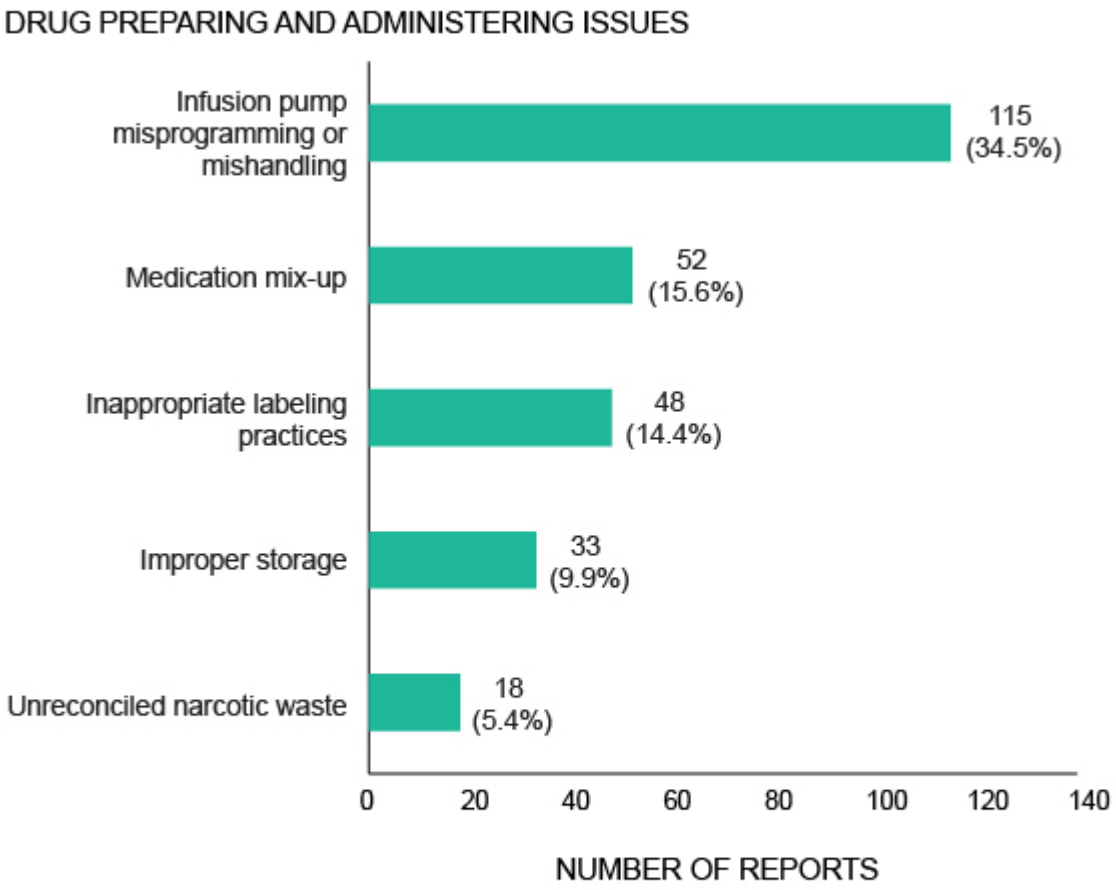
Dose was charted in MAK [medication administration check] before medication was delivered. Did the vial scan? The dose was not the same as the vial. Was this order overridden? Did the nurse notice that the dose was not 1,000 mg? Acetaminophen IV 1,000 mg was ordered for patient. Patient weighed 43 kg so I called surgery to change dose to 650 mg and made the dose. When I went to deliver the dose to pacu I noticed that the dose was already charted by the pacu nurse. She had pulled a 1 g vial from [the automated dispensing cabinet] and was priming the tubing as I arrived on the floor. I explained to her that I called to get the dose changed due to the patient's weight. She threw out the 1 g dose and hung the 650 mg dose instead.

IV acetaminophen charted as 10,000 mg. Alert for greater than 4 g populated into patient chart.

Medication Preparing and Administering

More than a quarter (29.3%, n = 333 of 1,137) of all reports involved issues that occurred while handling medications during preparing and administering. These issues included misprogramming of infusion pumps, medication mix-ups, and mislabeled, unlabeled, or otherwise unidentifiable medications (Figure 5).

Figure 5. Most Common Drug Preparing and Administering Issues in Events Occurring in the Perioperative Setting (N = 333)



Note: Data reported through the Pennsylvania Patient Safety Reporting System, 2017. Percentages in the figure are based on N = 333. The number of events (n = 266 of 333, 79.9%) represented in the figure correspond to the five most common drug preparing and administering issues involved in medication error events occurring in the perioperative setting.

MSI 352

More than one-third (34.5%, n = 115 of 333) of preparation and administration errors were associated with inappropriate use of smart infusion pumps (i.e., infusion devices with dose error reduction software and a programmable drug library to enhance patient safety during administration of injectable products[17]). Almost half (49.6%, n = 57 of 115) of these were due to misprogramming of the medication in the pump library or otherwise misusing the drug library.

The second most common type of infusion pump errors were due to physical disturbances of these devices, including line disconnects or pump malfunction during patient transfer (18.3%, n = 21 of 115).

Medication mix-ups (e.g., accidentally swapping one medication for another while a provider is handling several medications at one time either inside or outside the sterile field[18]) accounted for 15.6% (n = 52 of 333) of preparing and administering error reports. Following are examples of mix-ups that occurred in the OR, all of which are harm score D according to PA-PSRS harm score taxonomy:

During general anesthesia induction, a patient received neostigmine 5 mg IV instead of succinylcholine 100 mg IV. This was attributed to the similar colored label on both pre-filled syringes.

Provider drew medication up into incorrect pre-labeled syringe. Dilaudid [HYDROmorphone] administered preop instead of intraop.

Midazolam administered intraop instead of preop.

Wrong medication given. Vecuronium 8 mg was given in error in attempt to give 1.5 mg cefazolin. Upon reconstituting second vial labeled cefazolin 1 g, I realized that the first vial was vecuronium; however, I had already administered it to the patient. At end of case, patient had 2/4 post tetanic twitches, which met criteria for reversal with sugammadex [Bridion®] 4 mg/kg, for a total dose of 300 mg of sugammadex administered. After 3-4 minutes patient had 4/4 twitches and sustained tetany. Pt resumed spontaneous respirations and subsequently met criteria for extubation, and was transferred to the PACU. Aside from human error, contributing factors include look-alike vials next to each other in the pyxis that both require reconstitution.

Analysts determined that intraoperative labeling practices were involved in at least 14.4% (n = 48 of 333) of events. Following are examples of PA-PSRS reports involving mislabeled medications:

Pt presented for planned same-day surgery. Upon arrival to OR room, patient complained of headache. CRNA [certified registered nurse anesthetist] gave 2 mL of syringe labeled fentaNYL. Immediately became unresponsive and skin color turned dusky. CRNA initiated bag mask ventilation. Pulse ox applied and reading greater than 95%. Oral airway was placed. Anesthesiologist arrived and pt was intubated as planned without difficulty. Vital signs stable. Procedure completed without issue. Pt discharged to home as planned. Investigation found there were 2 syringes labeled as fentaNYL and no syringes labeled as rocuronium. Presumed that pt received 20 mg of rocuronium instead of intended 100 mcg of fentaNYL.

During a liver transplant procedure, an albumin and lactated ringer's cold perfusion bag was requested. After the bag was hung by the circulating nurse, a scrub nurse noticed that the labeling was unreadable. The bag had been prepared by the previous circulating nurse and labeled illegibly with a piece of silk tape, as the labels for medication additive were unavailable at the time it was prepared. Upon further investigation, the scrub nurse discerned the label contained only the patient name and the incorrect concentration of albumin, and that in addition to improper labeling the wrong perfusion mixture had been hung.

Almost 10% (9.9% n = 33 of 333) of error reports categorized under preparing and administering were due to improper storage of medications. Many of these involved automated dispensing cabinets (ADCs) and instances in which a medication was accidentally stocked or returned to the wrong pocket or bin in the ADC. The following is an example PA-PSRS reports involving an error due to improper storage:

Nursing noted in the medication dispensing machine that there were 5 mL and 1 mL vials in same pocket. The 5 mL and 1 mL have the same concentration. Patient received correct dose.

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* The details of the PA-PSRS event narratives in this article have been contextually deidentified to preserve confidentiality.

Discussion

Medication errors are rarely the result of an isolated mishap. Instead they are usually the outcome of a number of factors that lead to system-level failure.[19] In the perioperative setting, medications are often ordered and administered without the use of CPOE, independent-double checks, smart infusion pump devices, or bar-code medication administration (BCMA), which are common standard safety checks used in other areas of the hospital.[6]

The margin for human error is narrow when relying on a single provider to navigate this complex, multistep process with no redundancies and workflow challenges that preclude use of these patient safety technologies.[6] Yet, in the OR, the anesthesia provider is often the sole provider responsible for the medication use processes of drug ordering, dispensing, preparation, administration, and documentation.[20] Additional circumstances that impact medication administration in the OR include the need for ongoing titration of doses and rapid changes in the patient's condition.

The most common reported medication error event subtypes were "Other" and "Wrong dose/over dosage." Based upon information contained in the event descriptions, nearly all the event subtypes "Other" that were subcategorized by analysts could have been reported using an existing event type. High-alert medications were involved in fewer than half of events. This finding was initially surprising, considering that many high-alert medications, such as neuromuscular blocking agents and inhaled general anesthetics, are used in the perioperative setting. However, it is possible that medication errors with these agents might be mistaken for rapid changes in patient condition during procedures. Also, most high-alert medications administered in the OR are given directly by anesthesia staff. Depending upon the reporting culture within the anesthesia department, events involving high-alert medications may not be reported. The number of events involving high-alert medications was also offset by many reports about antibiotics, which may be driven by the Surgical Care Improvement Project (SCIP) antibiotic-related measures maintained by the Joint Commission.[21]

Preoperative orders, including antibiotics, analgesics, and anticoagulants (e.g., subcutaneous heparin for prophylaxis of thrombosis), are vulnerable to dose omissions if a patient is transferred from the preoperative setting before the dose is administered. This is especially true when medications are to be administered prior to transport to the OR or ordered to be delivered on call to the OR. Conversely, there is a risk that medication may be administered too early when orders are placed well in advance of the scheduled case. In previous PA-PSRS data analyses, there have been issues reported concerning medications, such as anticoagulants, that are temporarily "held" for scheduled tests or procedures but are not restarted as intended once the procedure is complete.[22,23]

A 2017 literature review of medication errors in perioperative studies indicated that within the OR, more than 70% of medication errors were attributed to substitution (i.e., labeling mistakes and syringe swaps; mix-ups), wrong dose, and wrong medication given.[18] Although these types of errors were not the most common in the current analysis of PA-PSRS data, analysts did find several instances of these types of errors. Mix-ups were attributed to unsafe labeling practices or accidentally drawing up the wrong medication into a pre-labeled syringe. According to the article "ISMP Safe Practice Guidelines for Adult IV Push Medications," there is inherent risk for medication errors when labeling empty syringes prior to use.[24]

Efficient and complete interdisciplinary communication impacts patient care in all settings, including the perioperative setting where poor handoffs may lead to adverse patient outcomes due to information loss.[3] Effective communication is made more difficult given the varied locations from which a patient can enter into the perioperative patient flow and the number of and types handoffs that take place during a patient's journey through the perioperative setting (see Figure 1 in the online article (https://www.apsf.org/article/all-handoffs-are-not-the-same-what-perioperative-handoffs-do-we-participate-in-and-how-are-they-different/) for an illustration of perioperative handoffs and transitions). There may be different types of preoperative courses, and according to these reports, handoff communication may not routinely occur at each step. For example, some reports illustrated that there was no standardized process for handoff between PACU and OR nurses. Even intraoperatively, handoffs are necessary when providers take relief breaks or change shifts. Postoperative transitions are like those that occur preoperatively because the patient may be moved or discharged to any number of locations, including potentially staying in the PACU until the next transfer.

Working towards complete and accurate documentation is critical in mitigating medication errors within the perioperative setting, including the OR. Specialized anesthesia EHR systems called Anesthesia Information Management Systems (AIMS) have been implemented in many facilities to capture intraoperative patient data.[25] Although AIMS have become increasingly more sophisticated, their ability to transmit data to and from an EHR remains vendor-specific, and it is unknown how many health systems and vendors are currently managing this information exchange. A health system might be using an EHR that does not communicate consistently, or at all, with

the AIMS, rendering the direct transfer of information impossible. These issues may be reflected in the PA-PSRS data. For example, in several reports, an antibiotic was administered in the OR, but the documentation was inaccessible to the pharmacist, who was then unsure of the correct time for the next dose.

When documentation errors are discovered upon chart review, it is often too late to resolve the discrepancies, because they are nearly impossible to reconcile once the patient has left the perioperative setting. Some of the documentation errors observed involved recorded doses of 100-fold overdoses (e.g., acetaminophen 10,000 mg IV). Improved clinical decision support within anesthesia applications may help catch some of these errors.

The Anesthesia Patient Safety Foundation (APSF) recently has encouraged hospital administrations to work with vendors to augment the handoff process with electronic tools—including applications for mobile devices—that can interface with the EHR/AIMS and support adequate documentation of patient information and drug administration.[26] Along with improvements in EHR/AIMS, providers may consider incorporating other technology routinely used in other areas of the hospital, such as BCMA and smart infusion pumps, into the perioperative setting. A 2018 ISMP survey of more than 1,000 hospitals in the United States found that more than 90% of those hospitals already employ smart pumps.[17]

Limitations

This analysis is limited to reports submitted through PA-PSRS and identified by reporting facilities to have occurred in a perioperative setting. The findings of this analysis may not be generalizable to all perioperative settings because there were very few reports from outpatient and ambulatory surgical centers. Consistent with the limitations of all error reporting programs, the quantity and quality of reports are highly dependent on (1) the ability of each reporting facility to identify events and submit complete and accurate information and (2) the ease of use of the reporting system (i.e., submitting reports is not a cumbersome or onerous process). Although the narrative fields of the reports help analysts discern what happened during the event, they often do not contain details describing how the event deviated from the standard operation or which factors contributed to the event.

Risk Reduction Strategies

Organizations and healthcare facilities can strive to identify system-based causes of errors associated with patient care in perioperative settings. Training and education are commonly recommended to prevent errors, but this strategy, while important, is less reliable due to being heavily influenced by individual performance. System-based improvements such as constraints and standardization are more effective and produce results with less variability. Consider the strategies described below, which are based on a review of current literature, events submitted to the Authority, and observations from ISMP:

- Employ BCMA across all patient care areas, including intraoperative areas and the PACU, as a system-wide, high-leverage strategy to prevent errors. Standardize the workflow for electronic entry of intraoperative orders to support BCMA. Consider implementing barcode-assisted syringe labeling systems, which replace manual syringe labeling by producing a label upon product scan at the time that the medication is drawn up into a syringe, in order to facilitate use of BCMA.[6]
- Evaluate current handoff procedures for patient transitions to, from, and within perioperative care areas for vulnerabilities. Redesign and standardize handoff procedures to reduce the risk that incomplete or inaccurate information (e.g., failure to account for patient allergies or the timing of previous medication doses) is exchanged.

- Establish a procedure for evaluating infusion pump settings and pump stability (i.e., make sure there are no line disconnections) prior to patient transfer, during transfer, and upon arrival at the new care unit in the pre-, intra-, and postoperative care paths.[3]
- Work with the organization's EHR/CPOE/AIMS and mobile-application vendors to optimize and streamline patient information exchange among these systems, as well as facilitate rapid and accurate documentation of medication administration.[26] Ensure that the systems support accurate exchange of information for all types of medication orders (e.g., PCA, continuous infusions, antibiotics). Also, optimize clinical decision support capabilities in these systems.
- Avoid pre-labeling empty syringes prior to intraoperative use and develop institution-specific practices and protocols for drug handling and labeling in the procedural areas. Verify each medication and label at the time of preparation.[27]
- Standardize stock and use pre-filled syringes supplied by manufacturers to minimize risks from mislabeling. When using pre-filled syringes from outsources (e.g., 503b pharmacies), purchase and use syringes that follow USP <7> labeling requirements to list the concentration as the total amount of drug per the total volume in the syringe, as is required for all commercial manufacturers.[27] Also, consider storing look-alike products separate from one another when feasible.

Conclusion

In-depth analysis by the Authority of medication errors associated with the perioperative settings found that wrong dose/over dosage and dose omission errors were the most commonly reported types of events during calendar year 2017. The two drug classes most commonly associated with error events were analgesics and antibiotics, and the most frequently cited drug was cefazolin. More than three-fourths of error reports were attributable to a breakdown in communication, transitions of care, handoffs, medication ordering processes, and lack of adequate documentation. Risk reduction strategies in the future may consider an evaluation of the full care path (i.e., pre-, intra-, and postoperative) that patients travel when undergoing surgical procedures. Organizations can use the information in this report to assess safety gaps in their current perioperative workflows and processes to minimize risk to patients and design systems to prevent errors from occurring.

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